FIRE DATA ANALYSIS FOR ALL COAL MINING CATEGORIES

UNDERGROUND COAL MINE FIRES

Table 1 and figure 1 show the number of fires and fire injuries that occurred in underground coal mines by state during 1990–1999. Table 1 also shows by state the risk rates, employees' working hours, lost workdays, and coal production. Overall, 87 fires occurred in 12 states. Twenty-seven of those fires caused 34 injuries (the yearly average was 8.7 fires and 3.4 injuries). One fire and one injury involved a contractor. The underground mine fires required 25 mine rescue team interventions and 30 mine/section evacuations followed by 13 mine/section sealing/flooding/CO_2/N_2 gas injections. The Ewhr value was $1{,}003 \times 10^6$ hr (Irr = 0.007), the CP value was $4{,}008 \times 10^6$ st (Frr = 0.022), and the LWD value was 208.

Virginia had the most fires (15 fires and 7 injuries). Pennsylvania had the most fire injuries (12 fires and 9 injuries), followed by Kentucky (12 fires and 6 injuries), and Alabama (12 fires and 4 injuries). Among these states, Alabama had the highest fire risk rate value (Frr = 0.073), whereas Pennsylvania had the highest injury risk rate value (Irr = 0.016).

Table 2, partly illustrated in figure 2, shows by time period the number of fires, fire injuries, risk rates, employees' working hours, lost workdays, and coal production. The number of fires and fire injuries show a decrease followed by an increase during the five time periods (see table 2 and figure 2). This was accompanied by a decline in employees' working hours throughout the periods and an overall small decrease in coal production. The Irr and Frr values follow patterns similar to those shown by the fire and injury values.

By comparison, data from Pomroy and Carigiet [1995] show that during 1978–1992 a total of 11 states were involved in 164 underground coal mine fires (yearly average, 10.8) with 43 injuries (yearly average, 2.9) and 27 fatalities (yearly average, 2; however, the 27 deaths occurred during a single fire caused by an overheated air compressor [MSHA 1984]). The CP value was $5{,}340 \times 10^6$ st (yearly average, 356×10^6 st) (Frr = 0.031). Data on employees' working hours and injury risk rates were not available.

Tables 3–8 show the number of fires by ignition source, method of detection and suppression, equipment involved, location, and burning material by time period. Figure 3 shows the major variables during 1990–1999. Table 9 shows the number of fire injuries per number of fires causing injuries and total fires by year, ignition source, equipment involved, and location.

Table 1.—Number of fires, fire injuries, and risk rates for underground coal mines by state, employees' working hours, lost workdays, and coal production, 1990–1999

State[1]	No. fires[1]	No. injuries[1]	LWD[2]	Ewhr,[2] 10^6 hr	CP,[2] 10^6 st	Frr[3]	Irr[3]
Alabama	12	4	6	67	165	0.073	0.012
Colorado	7	1	4	20	148	0.047	0.01
Illinois	12	1	6	96	403	0.03	0.002
Indiana	1	1	—	5	24	0.042	0.04
Kentucky	12	6	1	245	948	0.013	0.005
Ohio	1	—	—	32	133	0.0075	—
Pennsylvania	12	9	14	116	456	0.026	0.016
Tennessee	2	—	—	9	21	0.095	—
Utah	1	—	—	34	252	0.004	—
Virginia	15	7	140	96	291	0.052	0.015
West Virginia	9	5	37	271	1,131	0.008	0.004
Wyoming	3	—	—	3	23	0.13	—
All other states	—	—	—	9	13	—	—
Total	87	34	208	1,003	4,008	[3]0.022	[3]0.007

[1]Derived from MSHA "Fire Accident Abstract" and "Fire Accident Report" publications.
[2]Derived from MSHA "Injury Experience in Coal Mining" publications.
[3]Calculated according to USBM and MSHA formulas reported in the "Methodologies" section.

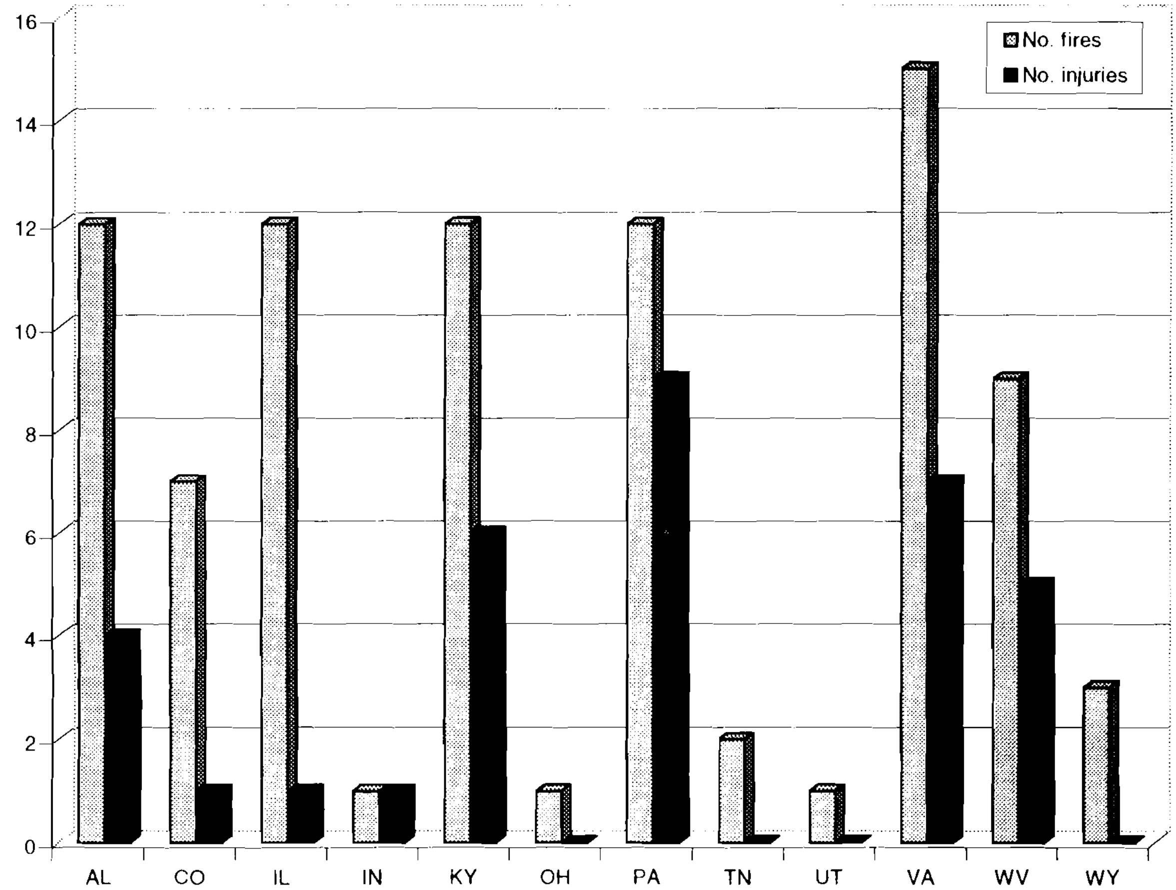

Figure 1.—Number of fires and fire injuries for underground coal mines by state, 1990–1999.

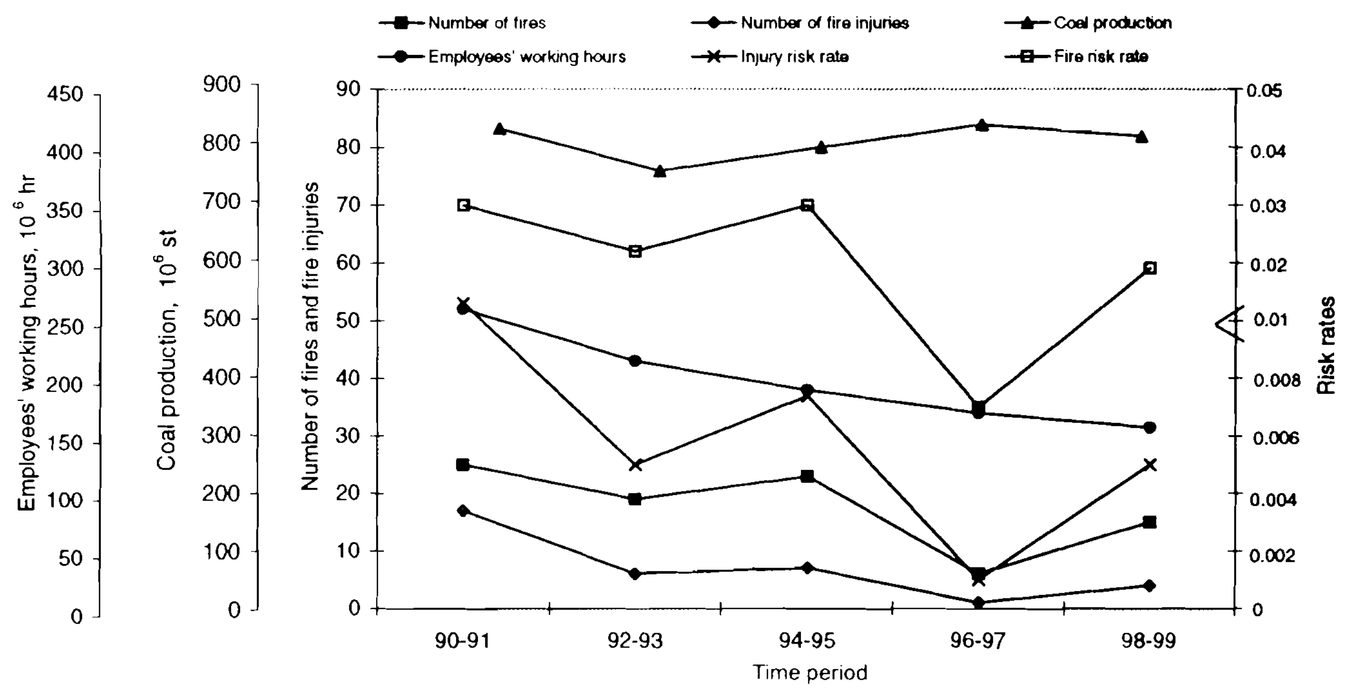

Figure 2.—Number of fires, fire injuries, risk rates, and coal production for underground coal mines by time period and employees' working hours, 1990–1999.

Table 2.—Number of fires, fire injuries, and risk rates for underground coal mines by time period, employees' working hours, lost workdays, and coal production. 1990–1999

	Time period					
	90-91	92-93	94-95	96-97	98-99	90-99
Number of fires[1]	25	18	23	6	15	87
Number of fire injuries[1]	17	5	7	1	4	34
LWD[2]	121	45	12	8	22	208
Ewhr,[2] 10^6 hr	257	209	196	179	162	1,003
CP,[2] 10^6 st	824	752	792	830	810	4,008
Frr[3]	0.03	0.024	0.03	0.007	0.019	[3]0.022
Irr[3]	0.013	0.005	0.007	0.001	0.005	[3]0.007

[1]Derived from MSHA "Fire Accident Abstract" and "Fire Accident Report" publications.
[2]Derived from MSHA "Injury Experience in Coal Mining" publications.
[3]Calculated according to USBM and MSHA formulas reported in the "Methodologies" section.

Table 3.—Number of fires for underground coal mines by ignition source and time period, 1990–1999

Ignition source	Time period 90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	90-99 No. fires
Flame cutting/welding spark/slag/flame[1]	8	2	3	2	2	17
Spontaneous combustion[2]	4	2	4	3	2	15
Electrical short/arcing/explosion[3]	5	7	9	1	6	28
Conveyor belt friction	1	5	5	—	4	15
Heat source	—	—	1	—	—	1
Overheated oil/grease	2	—	—	—	—	2
Mechanical malfunction/friction	3	1	1	—	—	5
Flammable liquid/refueling fuel on hot surfaces	1	—	—	—	—	1
Hydraulic fluid/fuel on equipment hot surfaces	—	1	—	—	—	1
Other	1	—	—	—	1	2
Total	25	18	23	6	15	87

[1]This source usually caused fires involving welders' clothing or oxyfuel/grease. However, in one instance sparks/hot slag/flames caused a methane ignition followed by a large fire requiring firefighting intervention and mine/section evacuation and sealing. In another instance, undetected hot slag caused a large fire requiring firefighting intervention and mine evacuation and sealing, followed by a methane explosion.
[2]This source at least twice was accompanied by methane explosions.
[3]This source caused 12 mobile equipment fires.

Table 4.—Number of fires for underground coal mines by method of detection and time period, 1990–1999

Method of detection	Time period 90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	90-99 No. fires
Visual method:						
Flames/flash fires	2	1	3	—	—	6
Sparks	7	2	3	1	2	15
Smoke	3	4	2	—	1	10
Late smoke detection	7	9	12	2	6	36
CO/H_2 gas sampling	1	1	2	2	1	7
Touched hot spots	1	—	—	—	1	2
CO/smoke belt detection system	—	—	1	—	—	1
Mine-wide monitoring system	—	—	—	—	1	1
Undetected	1	—	—	—	1	2
Explosion[1]	3	1	—	1	1	6
Power loss	—	—	—	—	1	1
Total	25	18	23	6	15	87

[1]Includes methane ignition, electrical cable, and starter box explosions.

Table 5.—Number of fires for underground coal mines by suppression method and time period, 1990–1999

Suppression method	Time period 90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	90-99 No. fires
Mine/section sealing/flooding/CO_2/N_2 gas injections	3	2	3	2	3	13
Portable fire extinguisher	4	6	5	1	1	17
Water	6	2	8	1	3	20
Manual/FE[1]	7	1	1	—	2	11
FE-dry chemical powder/rock dust/water[2]	2	6	5	1	3	17
Machine water spray	2	—	—	—	—	2
FSS-dry chemical powder-water	—	1	1	—	1	3
Destroyed/heavily damaged[3]	1	—	—	1	2	4
Total	25	18	23	6	15	87

FE Portable fire extinguisher.
FSS Machine fire suppression system.
[1]Methods used by welders to extinguish clothing or oxyfuel/grease fires.
[2]In two instances, foam was also used.
[3]Due to failure of other firefighting methods, late fire detection, or undetected fires.

Table 6.—Number of fires for underground coal mines by equipment involved and time period, 1990–1999

Equipment	Time period 90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	90-99 No. fires
Oxyfuel torch	8	2	4	2	2	18
Beltline/drive/pulley/feeder	3	4	5	—	4	16
Electrical system/cable/starter/breaker/ transformer/rectifier/voltage box	4	4	2	—	3	13
Generator/pump/fan	1	1	1	—	—	3
Mobile equipment[1]	4	5	7	1	4	21
Other[2]	5	2	4	3	2	16
Total	25	18	23	6	15	87

[1]Includes scoops, bolters, continuous miners, shearers, ore cart, shuttle cars, 3-wheelers, jeeps, railrunners, trolleys, locomotives, and power scalers.
[2]Includes nonequipment (mostly coal piles).

Table 7.—Number of fires for underground coal mines by location and time period, 1990–1999

Location	Time period 90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	90-99 No. fires
Flame cutting/welding areas[1]	6	2	3	2	2	15
Gobline/sealed/abandoned/coal pit areas	3	2	3	1	1	10
Belt entry/feeder/slope/portal branch areas	6	5	7	—	6	24
Longwall panel/headgate/main return	2	—	1	3	1	7
Haulage/track rails	2	1	—	—	—	3
Power station/rectifier areas	—	1	—	—	1	2
Generator/transformer/fan/breaker/pump areas	1	2	2	—	1	6
Charging station	—	—	3	—	—	3
Mining face/intersection/crosscut areas	4	—	3	—	—	7
Maintenance areas	1	1	1	—	—	3
Mobile equipment working areas[2]	—	4	—	—	3	7
Total	25	18	23	6	15	87

[1]Includes belt entry, feeder, drive and pulley areas, shops, elevator shafts, overcasts, longwall face/headgate, and mobile equipment maintenance areas.
[2]Includes haulage, bolting, and transportation areas.

Table 8.—Number of fires for underground coal mines by burning material and time period, 1990–1999

Burning material	Time period 90-91 No. fires	92-93 No. fires	94-95 No. fires	96-97 No. fires	98-99 No. fires	90-99 No. fires
Coal/coal dust	4	2	6	3	1	16
Electrical cables/wires/starter/voltage box/rectifier/ electrical insulation/breaker/transformer/batteries	5	7	7	1	6	26
Belt/feeder/drive/pulley	3	2	4	—	4	13
Oxyfuel/grease/clothing	7	2	2	1	1	13
Elevator shaft/motor	1	3	2	—	—	6
Flammable liquids/refueling fuel/methane	1	1	1	1	2	6
Hydraulic fluid	—	1	1	—	—	2
Gearbox	1	—	—	—	1	2
Oil/resin	3	—	—	—	—	3
Total	25	18	23	6	15	87

Table 9.—Number of fire injuries per number of fires causing injuries and total fires in underground coal mines by year, ignition source, equipment involved, and location, 1990–1999

Year	No. fires causing injuries	No. total fires	No. fire injuries	Ignition source	Equipment	Location
1990	2	16	8	Electrical short/arcing/battery explosion	Electrical cables/starter/ voltage box/battery.	Loading track/charging station.
	2	—	2	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
1991	1	9	1	Refueling fuel on hot surfaces	Mobile equipment[2]	Maintenance areas.
	4	—	4	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
	1	—	1	Electrical short/arcing	Pump unit	Pump station.
	1	—	1	Conveyor belt friction	Beltline/pulley	Belt entry.
1992	2	14	3	Electrical short/arcing	Power cables/mobile equipment[2]	Trolley track rails/ transportation areas.
1993	2	4	2	Electrical short/arcing	Power breaker/mobile equipment[2]	Pump station/bolting areas.
1994	1	11	1	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
	2	—	2	Electrical short/arcing	Power cable/mobile equipment[2]	Charging station/ mining areas.
	1	—	1	Conveyor belt friction	Beltline/drive/pulley	Belt entry.
1995	1	12	1	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
	1	—	1	Heat source	Heater	Mining intersection.
	1	—	1	Conveyor belt friction	Coal feeder/motor	Belt entry.
1996	—	3	—	—	—	—
1997	1	3	1	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
1998	—	5	—			—
1999	1	10	1	Conveyor belt friction	Beltline/drive pulley	Belt entry.
	1	—	1	Flame cutting/welding spark/slag/flame	Oxyfuel torch	Flame cutting/welding areas.[1]
	1	—	1	Hot surface	Mobile equipment[2]	Maintenance areas.
	1	—	1	Electrical short/arcing	Electrical power cables	Power station.
Total	27	87	34			

[1]Includes beltlines, longwall mining face, and mobile equipment maintenance areas.
[2]Includes bolters, scoops, jeeps, trolley, railrunners, and shuttle cars.

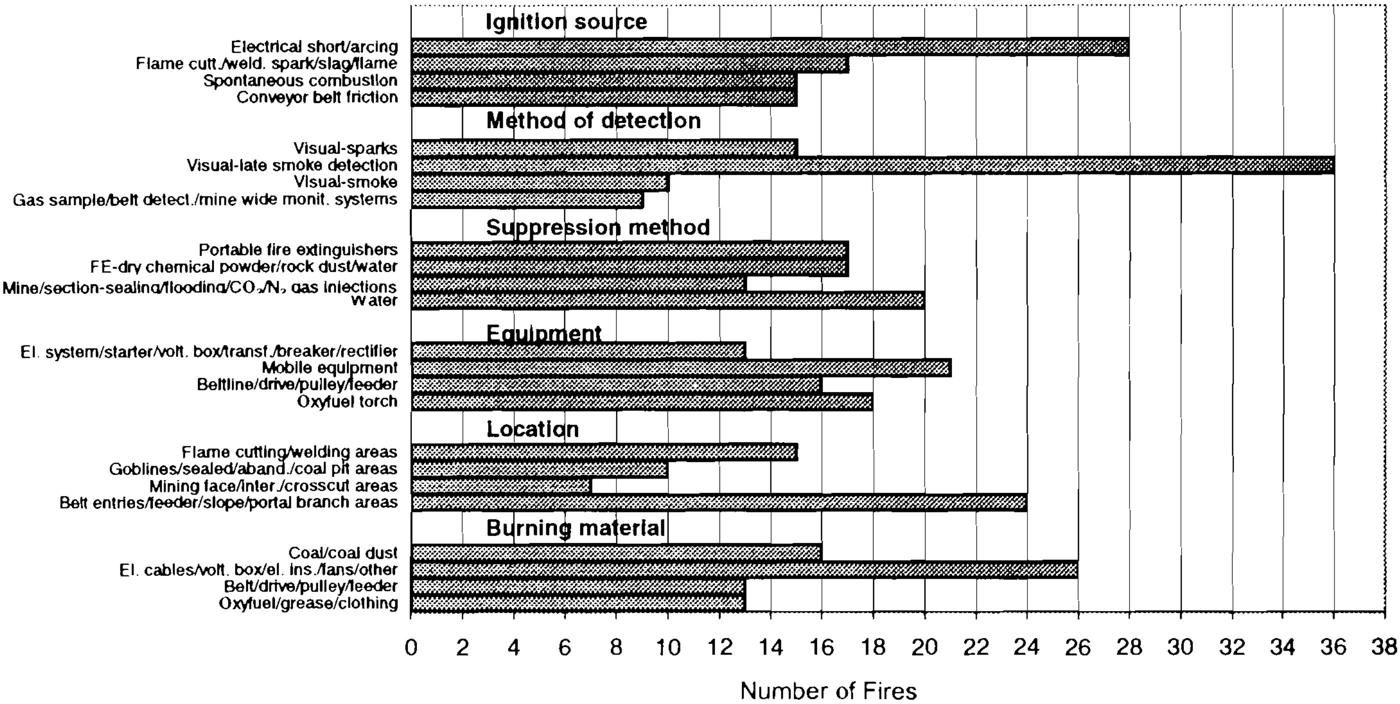

Figure 3.—Major variables for underground coal mine fires, 1990–1999. (FE = portable fire extinguisher)

Ignition Source

The number of fires and fire injuries by ignition source and time period is shown in tables 3 and 9. Electrical short/arcing caused the most fires (28 fires or 32% with 17 injuries). These occurred in electrical power and cable systems, power circuits and breakers, belt transformers, grounded cables and wires, batteries, high-voltage boxes, power generators, and rectifiers. The fires involved beltlines, drives, and pulleys; power centers and power units; and mobile equipment. Twelve mobile equipment electrical fires became large fires (at times involving the hydraulic lines) that required firefighting interventions and mine/section evacuations.

Another ignition source was flame cutting/welding spark/slag/flames (18 fires or 21% with 10 injuries). This source caused fires usually involving welders' clothing or oxyfuel/grease (grease embedded in the equipment's mechanical components). However, in at least one instance sparks/hot slag/flames caused a methane ignition followed by a large fire, which required firefighting intervention and mine/section evacuation and sealing. In another instance, undetected hot slag caused a large fire, which required firefighting intervention and mine evacuation and sealing followed by a methane explosion.

Friction of conveyor belts against pulleys, drives, rollers, idlers, and bearings resulted in 16 fires (18%) with 4 injuries. This source, usually detected long after the fire had started, caused extensive damage to beltlines, drives, and pulleys and disruption of mining operations.

Spontaneous combustion of coal resulted in 15 fires (17%). This source, usually detected long after the fire had started, caused fires involving goblines and sealed and abandoned areas, which severely disrupted mining operations. In at least two instances the spontaneous combustion fires were accompanied by methane explosions and required mine rescue team interventions and mine/section evacuations.

Other ignition sources were flammable liquid/refueling fuel on hot surfaces (four fires), mechanical malfunction/friction (two fires), overheated oil/grease (two fires), heat source (one fire), and hydraulic fluid sprayed onto mobile equipment hot surfaces (one fire). The latter fire grew out of control and required mine rescue team intervention.

During the first period (1990–1991), the largest number of fires were caused by the flame cutting welding spark/slag/flame source. During the second, third, and fifth periods, the largest number of fires were caused by the electrical short/arcing/explosion source. During the fourth period, the largest number of fires were caused by spontaneous combustion (see table 3). By comparison, data from Pomroy and Carigiet [1995] for 1978–1992 show that the leading ignition sources in underground coal mine fires were electrical short/arcing, belt friction, flame cutting/welding spark/slag, and spontaneous combustion.

Method of Detection

Table 4 shows the number of fires by method of detection and time period. The most frequent methods were miners who saw smoke long after the fire had started, followed by welders who saw sparks and miners who saw smoke shortly after the fires had started. Other methods of detection were operators who saw the fires when they started as flames/flash fires, miners who heard an explosion or touched hot spots, and operators who experienced power loss. Nine fires were detected by CO/H_2 gas sampling, CO/smoke belt fire detection systems, or mine-wide monitoring systems. Two fires were undetected.

During the first period, the largest number of fires were detected by sparks and detected late by smoke. During the second, third, and fifth periods, the largest number of fires were detected late by smoke. During the fourth period, the largest number of fires were detected late by smoke and by CO/H_2 gas sampling (see table 4). By comparison, data from Pomroy and Carigiet [1995] for 1978–1992 show that the most frequent methods of detection for underground coal mine fires were miners who saw the fires when they started or saw smoke shortly after they had started.

Suppression Method

Table 5 shows the number of fires by suppression method and time period. Usually more than one agent was used to fight a fire. The most common methods were water or portable fire extinguishers alone and portable fire extinguishers with dry chemical powder, rock dust, and water. In two instances, foam was also used. In 13 instances, mine/section sealing/flooding/CO_2/N_2 gas injections were required. Other methods included manual techniques with or without portable fire extinguishers (welders' methods to extinguish clothing or oxyfuel/grease fires) and machine water sprays.

Of note is that portable fire extinguishers alone, although used upon discovery of the fires, were successful in extinguishing only small fires involving grease, flammable liquids, power units, engine/mechanical malfunctions, oxyfuel/grease, and overheated oil. Three pieces of mobile equipment involved in fires had machine fire suppression systems. Dual activation (two activations) of machine fire suppression and motor deenergization systems was successful in temporarily abating the fires. However, the flames reignited, fueled by the flow of pressurized fluids entrapped in the lines (not affected by the motor deenergization operation).

Twelve of the mobile equipment electrical fires (which in at least one instance affected the hydraulic lines) and one hydraulic fluid fire became large fires because of unavailability of effective machine fire suppression systems, lack of an emergency line drainage system, or lack of effective and rapid local firefighting response capabilities. Mine rescue teams (required for 25 of the fires), upon mine/section evacuation (required 30 times), fought the mobile equipment fires (5 times) and other large fires with dry chemical powder, rock dust, and water. In all, five fires destroyed or heavily damaged equipment (including two pieces of mobile equipment) because of failure of other firefighting methods, late fire detection, undetected fires, or fire size.

Other factors that determined the success of fire-suppressing agents were the time that elapsed between detection and application of agents and effective and rapid local firefighting response capabilities.

During the first period, the largest number of fires were suppressed manually with or without portable fire extinguishers or by water alone. During the second period, the largest number of fires were suppressed with portable fire extinguishers, dry chemical powder, rock dust and water or with portable fire extinguishers alone. During the third period, the largest number of fires were suppressed with water alone. During the fourth period, the largest number of fires were extinguished by mine/section sealing/flooding/CO_2/N_2 gas injections. During the fifth period, the largest number of fires were extinguished by mine/section sealing/flooding/CO_2/N_2 gas injections; by dry chemical, rock dust, and water; or by water alone (see table 5). By comparison, data from Pomroy and Carigiet [1995] for 1978–1992 show that the most common suppression methods used in underground coal mine fires were water, dry chemical powder, rock dust, and sealing with CO_2/N_2 gas injections.

Equipment Involved

Table 6 shows the number of fires by equipment involved and time period. The equipment most often involved was mobile equipment (e.g., scoops, shuttle cars, bolters, railrunners, continuous miners, trolleys, ore carts, jeeps, locomotives, shearers, three-wheelers, and power scalers). This was followed by oxyfuel torches; beltlines, pulleys, drives, and feeders; and electrical systems, cables, breakers, starters, rectifiers, voltage boxes, and transformers. Other equipment included pumps, generators, and ventilation fans. Sixteen fires did not involve equipment (mostly coal piles).

During the first and fourth periods, the largest number of fires involved oxyfuel torches. During the second and third periods, the largest number of fires involved mobile equipment. During the fifth period, the largest number of fires involved mobile equipment and beltlines, drives, pulleys, and feeders (see table 6). By comparison, data from Pomroy and Carigiet [1995] for 1978–1992 show that the equipment most often involved in underground coal mine fires were beltlines and drives, followed by flame cutting/welding equipment.

Location

Table 7 shows the number of fires by location and time period. Figure 3 shows the major fire locations during 1990–1999. The most common locations were belt entry, feeder, slope and portal branch areas, flame cutting/welding areas (at the longwall face and headgate, belt entries, feeders, shops, elevator shafts, overcasts, and mobile equipment maintenance areas), and goblines, sealed, abandoned, and coal pit areas. Other fire locations were the mining face, intersection, and crosscut areas; the longwall panel/headgate and main return areas; and mobile equipment working areas (haulage, bolting, and transportation areas). Generator and pump housing, belt transformer, fan and breaker areas, haulage and track rail areas, rectifier, charging and power stations, and maintenance areas were other locations affected by fires.

During the first period, the largest number of fires occurred at flame cutting/welding areas and at belt entry, feeder, portal branch, and slope areas. During the second, third, and fifth periods, the largest number of fires occurred at belt entry, slope, feeder, and portal branch areas. During the fourth period, the largest number of fires occurred at longwall panel, headgate, and main return areas (see table 7). By comparison, data from Pomroy and Carigiet [1995] for 1978–1992 show that the most common fire locations in underground coal mines were belt entry, working face, intake entry, and track haulage areas.

Burning Materials

Table 8 shows the number of fires by burning material and time period. The materials most often involved were electrical cables, starters, voltage boxes, rectifiers, electrical insulation, breakers, transformers, and batteries. These were followed by coal and coal dust; belts, feeders, drives, and pulleys; and oxyfuel, grease, and clothing. Other burning materials were flammable liquids, methane, elevator shafts and motors, oil and resin, hydraulic fluids, and gearboxes.

During the first period, the largest number of fires involved oxyfuel, grease, and clothing materials. During the second, third, and fifth periods, the largest number of fires involved electrical cables, wires, starters, voltage boxes, transformers, starters, and batteries. During the fourth period, the largest number of fires involved coal and coal dust (see table 8). By comparison, data from Pomroy and Carigiet [1995] for 1978–1992 show that the most frequent burning materials in underground coal mines were coal and coal dust, electrical insulation, oil and grease, conveyor belts and rollers, wood, rubber hoses, and tires.

Fire Injuries

Table 9 shows the number of fire injuries per number of fires causing injuries and total fires by year, ignition source, equipment involved, and location during 1990–1999. Overall, there were 34 injuries caused by 27 fires. The greatest number of fire injuries occurred in 1990 (10 injuries caused by 4 fires) and 1991 (7 injuries caused by 7 fires). The ignition sources that caused most of the fire injuries were electrical short/arcing, battery explosion, and flame cutting/welding spark/slag/flames. Other ignition sources were conveyor belt friction, heat source, and refueling fuel on hot surfaces. The equipment most often involved in fire injuries were electrical power cables, voltage boxes, oxyfuel torches, beltlines, drives, pulleys and feeders, and mobile equipment. The most common locations for fire injuries were pump, power and charging stations, mobile equipment working areas, flame cutting/welding areas, trolley track rails and transportation areas, and belt entries.

By comparison, data from Pomroy and Carigiet [1995] for 1978–1992 show that the ignition sources causing the most of the fire injuries were electrical short/arcing, belt friction, and flame cutting/welding sources. The equipment most often involved in fire injuries and fire fatalities included air compressors (which caused 27 fatalities during one fire), trolley power cables, and oxyfuel torches. The most common locations for fire injuries were main intakes, belt entries, longwall headgate, working faces, and track entries.

SURFACE OF UNDERGROUND COAL MINE FIRES

Table 10 and figure 4 show the number of fires and fire injuries occurring at the surface of underground coal mines by state during 1990–1999. Table 10 also shows by state the risk rate, employees' working hours, and lost workdays.

A total of 65 fires occurred in 10 states. Thirteen of those fires caused 12 injuries and 1 fatality (the yearly average was 6.5 fires and 1.2 injuries). Four fires and one fire injury involved contractors. The Ewhr value was 97×10^6 hr (Irr = 0.025); the LWD value was 6,206. Pennsylvania had the most fires (20 fires and 5 injuries), followed by West Virginia (16 fires and 1 fatality) and Kentucky (15 fires and 3 injuries). Among these states, Pennsylvania had the highest injury risk rate value (Irr = 0.095).

Table 11, partly illustrated in figure 5, shows by time period the number of fires, fire injuries, and fire fatalities; risk rates; employees' working hours; and lost workdays. The number of fires and fire injuries show a decrease followed by an increase during the five time periods, accompanied by a decline in employees' working hours throughout the periods (see table 11 and figure 5). The Irr values follow patterns similar to those shown by the injury values.

Tables 12–17 show the number of fires by ignition source, method of detection and suppression, equipment involved, location, and burning material by time period. Figure 6 shows the major variables during 1990–1999. Table 18 shows the number of fire injuries per number of fires causing injuries and total fires by year, ignition source, equipment involved, and location.

Ignition Source

The number of fires and fire injuries by ignition source and time period is shown in tables 12 and 18. The leading sources were hydraulic fluid/fuel sprayed onto equipment hot surfaces (11 fires or 17% with 1 injury), spontaneous combustion/hot coal (11 fires or 17%), and flame cutting/welding spark/slag/ flames (11 fires or 17% with 7 injuries). Three of the mobile equipment hydraulic fluid/fuel fires became large fires, which at times required fire department interventions. In at least two instances flames erupted in the cab, probably because of the ignition of flammable vapors and mists that penetrated the cab. Of note is that most of the hydraulic fluid/fuel fires were caused when hydraulic fluids sprayed onto equipment hot surfaces; subsequently, these fires involved the fuel lines. The flame cutting/welding spark/slag/flame source caused fires usually involving welders' clothing or oxyfuel/grease (grease embedded in the equipment's mechanical components). However, in one instance sparks/hot slag/flames caused a methane ignition followed by a large fire, and twice undetected hot slag caused coal belt fires. Other ignition sources were heat source (four fires), electrical short/arcing (four fires), conveyor belt friction (three fires), and overheated oil (one fire). Twenty ignition sources (mostly affecting facilities) were unknown.

During the first period, the largest number of fires were caused by hydraulic fluid/fuel sprayed onto equipment hot surfaces. During the second period, the largest number of fires were caused by spontaneous combustion/hot coal. During the third and fourth periods, the largest number of fires were caused by the flame cutting/welding spark/slag/flame source. During the fifth period, the largest number of fires were caused by flame cutting/welding spark/slag/flames, spontaneous combustion/hot coal, and hydraulic fluid/fuel sprayed onto equipment hot surfaces (see table 12).